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Optimizing Human Computer Interaction for Better Accessibility, Usability and Flexibility

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Abstract: ***Human Computer Interaction (HCI) is increasingly becoming a common phenomenon, as humans keep interacting with computing technology in diverse forms on a daily basis. Issues like ease of use, accessibility and usability gain precedence as the overriding objective is to make such systems more intuitive and user friendly. An important element of such endeavors is to provide avenues for special groups like geriatrics and specially abled people to utilise this technology through the use of innovations like haptics. Obviously a major determinant of success is going to be government policy. This is specially so for countries like India which are still in the process of carving out a niche for themselves in this field.***

Keywords: Human Computer Interaction (HCI), Interactivity, Accessibility, Usability, Haptics

1.Introduction

The guiding principle for HCI is "Ensuring system functionality and usability, providing effective user interaction support, and enhancing pleasant user experience. " The overarching goal is to achieve both organisational and individual user effectiveness and efficiency. To reach these goals, managers and developers need to be knowledgeable about the interplay among users, tasks, task contexts, information technology (IT), and the environments in which systems are used,"[1] HCI works based on four traits originating from the relationship between humans and computers, viz.,-the fit between the human operator, the computer and the task to be performed, the task itself, its performance and the well-being of the human being in terms of her comfort, health and safety.[2]

An important framework in this regard is provided by the Technology Acceptance Model (TAM) initially suggested by Davis[3] in 1989 and subsequently refined by Davis and others. TAM helps developers to evaluate how users may react to changes in information technology.

HCI design should take into consideration physical factors relating to the user like vision, hearing and touch. Special considerations will be needed in the case of differently-abled persons.

Attention also needs to be paid to the nature of the interface between human users and computers. These can take the form of natural language interfaces, question-and-answer interfaces, menus, form-fill interfaces, common language interfaces, graphical user interfaces, and so on.[4]

HCI offers us an interesting but very effective way of looking at how people deal with technology. Plenty of research has already taken place examining all the varied aspects of HCI. Some of these have been highlighted in the literature survey section.

Specifically, we intend to see how people relate to the computing technology that they utilise regularly. Some of the areas we would like to concentrate on include;

Ease of use

Convenience in using technology engenders confidence in the end-user. This is particularly so for special interest groups like children, females, the elderly and the specially-abled. This latter can constitute subsets within the overall investigation.

Applicability of the technology or system to its intended purpose

People will use any kind of technology only when they need it. And how the relevant technology helps them to perform the task will determine how easily they will embrace it.

[1]Carey et al., "The Role of Human Computer Interaction in Management Information Systems Curricula: A Call to Action." The Communications of the Association for Information Systems 13.1 (2004) p. 358

2 Kendall and Kendall, "System Analysis and Design", 8th Ed., Prentice Hall Press, 2010, pp.535-536.

[3]Davis Jr, Fred D. *A technology acceptance model for empirically testing new end-user information systems: Theory and results*. Diss. Massachusetts Institute of Technology,1986.

[4] Kendall and Kendall, Ibid.

Problems encountered in using the technology

A major discouraging factor in the adoption of technologies is the difficulties people may encounter in using it. If the modus operandi is not clear or is not easy, if the output is difficult to interpret or requires specialised knowledge, if the technology is rare or expensive, etc there may be issues in utilising the technology.

Responsiveness of the system

A system that provides fast response, especially when the job concerned has to be performed within a definite period, can be expected to be adopted faster by the target population. Responsiveness may also be desirable in case of specialised applications like those meant for new learners or specially-abled users.

The ability of the system to understand sensory inputs

While conventionally inputs to the system are based on devices like keyboards or touch, there can be situations where alternative modes of input may be necessary and/or may improve the quality of input, thus leading to better task performance. Thus it may be worthwhile considering auditory, haptic, or other such modes of input.

The role played by system design

The design of a work-based system has an intrinsic relationship with how the work may be performed. Leaving apart elements like ergonomics, the fundamental way in which the components of a computer-based system relate to one another, take inputs and outputs from each other and process these to provide the final result (s) to the end-user will determine the efficacy of the system. In fact HCI is influenced by a variety of related disciplines in this regard:

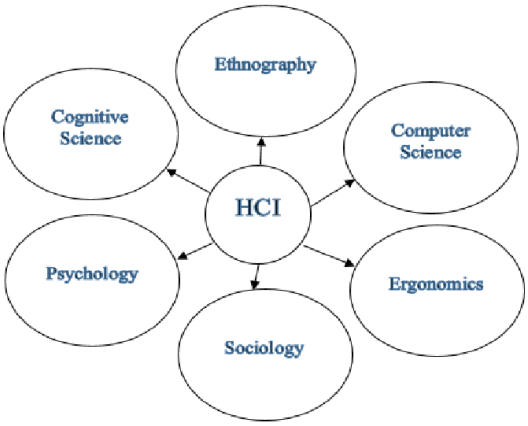

Figure 1[5]

The rest of the paper is organised as follows:

Section 2 describes some of the recent literature in this area. The next three sections relate to the theme of this paper, viz. the interactions between humans and computer technology. Section 3 considers interactions involving personal computing devices. Section 4 looks into innovations in touch based technology. Section 5 focuses on public interactions between humans and computer technology. Section 6 summarises the developments so far and lays down the path ahead.

2.Review of Literature

There is a substantial amount of literature with regard to HCI and related developments. Some of the recent contributions are highlighted hereafter.

Wescott (2010) examined the development of e-government in Asian countries. It considers some of the benefits accruing from e-government, including public sector reform and poverty reduction. The paper also compares implementations in the public and private sectors, while also looking into some of the challenges in this field. Earlier Holliday (2002) had provided a more concentrated look at the phenomenon, setting it in the context of development of information and communication technology in the ASEAN countries in the light of the south east Asian financial crisis. The author then goes on to study policy implementation in this connection, evaluating it in terms of government web sites. Warf (2014) has also provided a comparison of e-government implementation in Asian countries. Mukhoryanova et. al. (2016) extended the comparison across Western Europe and USA, in addition to Asia. The authors noted divergence of development of e-government applications in different geographical areas.

There have also been studies on the application side of e-government. Sharma (2007) has looked at how the Public Private Partnership (PPP) model has been utilised for overcoming the loopholes like non-availability of financial resources, technical and soft skills. In this connection, the paper considers four cases of successful implementation of e-government in Asia in terms of best practices and key learning. Goh et. al. (2008) argue that proper knowledge management is essential for facilitating knowledge flow between governments, individuals and organisations; hence effective implementation of knowledge management mechanisms becomes crucial. The authors propose an evaluation model for this purpose along with the constituent dimensions. Jati and Dominic (2009) have thrown some light on the quality of e-government websites of five Asian countries with the help of online diagnostic tools. The quality of a website has been defined in terms of the quality of service, the user perspective, the content perspective and the usability perspective. The conclusion was that the concerned websites were lagging behind with regard to performance and quality criteria. In a subsequent work (2010) they have provided an evaluation of website quality using the AHP paradigm. A related study was done by Kuzma et. al. (2009) where they focused on how government websites across a cross section of countries in the EU, Asia and Africa were accessible to specially abled persons. The inference was that the website design still left a lot to be desired in this matter. An interesting work has been done by Andersen (2009) where he has studied how the development of e-government has led to the decrease in corruption. Ali et. al. (2018) have

[5]Gobena, D. L. (2019). Human-Computer/Device Interaction. In Computer Architecture in Industrial, Biomechanical and Biomedical Engineering.

tried to establish whether there is a relationship between the development of e-government and the digital economy. The paper deduced the existence of a two way relationship. Moreover, it was found that in addition to social, economic, political, technological and demographic factors, the relationship may be moderated by national culture.

3.Interactions with Personal Computer Devices

At the base of any application is the way users interact with it. A simple way to represent this interaction is shown in Figure 1.

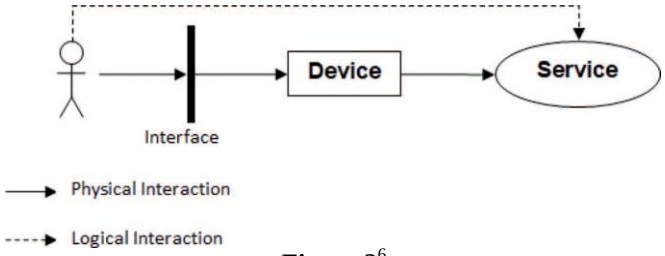

Figure 2[6]

In this particular paper we are including devices like PCs, laptops and notebooks. Formerly this area also included palmtops, but with the arrival of mobile phones, particularly smartphones, these have been phased out.

Computers first started as slow processing heat-producing bulky machines occupying an entire room or hall. With rapid miniaturisation there has been a progressive decrease in the size of the computer with a corresponding increase in its computing power. Both of these factors have made it easier to work with the device.

Attempts have been made towards designing different types of input devices that make it easier for the user to utilise the device according to the particular use. Thus, for example, joysticks were developed for use in gaming applications.

The arrival of laptops led to greater portability of the device, but it did not necessarily result in improved ease of operation. For example, operating the mouse pad is generally considered to be less easy compared to using the mouse itself for most people.

4.Equations Interactions with personal touch-based devices

E. A. Johnson was responsible for originating the concept of the touch screen computer as far back as 1965. The seventies witnessed the introduction of touch screen technology in the public domain with the arrival of the first ATMs and information kiosks. A major event was the appearance of the first touch screen computer introduced by HP in 1983.1982 saw the development of multi-touch systems.

Touch can be regarded as a double-edged sword. In some ways, touch-based devices may be thought to enable intuitive use. However, it is also a fact that some people (e. g. older users) may find it difficult to work with such devices. Touch screen systems have been infamous for being imprecise. Parallax and calibration problems have led to errors, invariably causing user frustration.

Touch devices have different parameters for judging based on HCI principles compared to other more traditional modes of operation of such devices. It is clear that in comparison to the previous category of devices, the operation of touch-based devices has less need for technical knowledge. The intuitive nature of touch devices implies that even somebody who has not been exposed to such devices can adapt fast just by working on them regularly. This very feature can also enable groups with limited motor abilities, such as specially-abled personnel, or elderly people, to work on such devices with greater freedom. This offers support to the hypothesis that alternative or less traditional modes of device use can be helpful for those who experience difficulties in operating in more traditional ways.

Proper and effective use of touch screens needs the consideration of several issues like greater accuracy, positioning of hands, utilisation of haptics, countering fatigue and fingerprints

5.Interactions with Public Devices

By public devices, we are referring to those within the public domain rather than on private premises or use. Examples include ATM kiosks or touch screens providing information about establishments within premises such as malls or zoos, or details of events being hosted simultaneously at any venue such as a convention. Such devices represent a different set of parameters compared to those applicable for personal devices. The stress here has to be more on accessibility, understandability and usability.

The intention here is to examine how HCI can be utilised to understand and improve the experience of working with computing devices.

A variety of activities have taken place in this regard. These have been divided into the following two groups. The first group relates to research looking into the human side of HCI. The second group covers the developments on the technical side that have contributed to the furtherance of HCI as a discipline.

(1) Perceptual Motor Interaction

In consonance with the information processing abilities of human beings themselves. Human beings themselves are active processors of information. Information processing analysis describes observed behaviour in terms of encoding of perceptual information, the utilisation of the encoded information by internal psychological systems and functional organisation of these subsystems.

(2) Human Information Processing

The interaction between humans and computers is based on the processing of information by human beings. The process

[6]Gobena, D. L. (2019). Human-Computer/Device Interaction. In Computer Architecture in Industrial, Biomechanical and Biomedical Engineering

is initiated by the human concerned issuing a command to the computer system with a view to the achievement of specific goals, which she has in mind. The command will lead to the initiation of software programs for accomplishing specific tasks. The resultant output should enable the user to proceed to the next step in the process; alternatively, the user has to enter another command to get the desired output.

(3) Inculcating Human Emotions in HCI

While emotions are a basic part of human nature, in the case of HCI, users were expected to work free of them so that they can work efficiently and rationally with computers. However, in recent times it has been realised that emotions may be a vital component moderating the interactions between humans and computer systems. A wide variety of emotions play a major role in every goal-directed computer-based activity. Through the use of inexpensive and efficient technologies that can take into account the physiological implications of emotions, along with substantial improvements in the speed and quality of signal processing have enabled computers to monitor the emotional state of the user on a real-time basis.

(4) Cognitive Architecture

Cognitive architecture relates to the process of using the knowledge of human behaviour, as obtained through cognitive psychology in the effective design of computer systems. This is easier said than done, as it demands building applied psychology that marries together theory, data and knowledge7. Bringing about this level of integration can be a very challenging proposition.

One of the major advances in this direction is the development of cognitive architecture. The expression 'cognitive architecture' refers to the overall structure and arrangement of the human cognitive system. It is a broad theory of human cognition based on a wide selection of experimental data based on humans and implemented as a running computer simulation program.

(5) Task Loading and Stress in Human Computer Interaction

Computer systems often support people working in stressful environments. It follows that there are important design issues regarding how information is provided to those working in such challenging situations. Stress relating to task loading can be a very significant issue vis-a-vis HCI.

(6) An Introduction to Captology

Computers have progressed far beyond their initial purpose of complex calculations. They have proceeded to become an important part of homes and offices. The development has led to new uses of interactive technology, including the use of computers for changing people's attitudes and behaviour; in other words, computers can be utilised in the demanding task of persuasion.

[7]Card, S. K., Moran, T. P., & Newell, A. (1983). *The Psychology of Human–Computer Interaction.* Hillsdale, NJ: Erlbaum.

(7) Human Error Identification in HCI

Errors are a common occurrence in the interactions with any kind of technology. Human error is often the fallback option in the absence of technical explanations. Design is the all-important factor in the reduction of human errors. The idea that design issues are behind the occurrence of most errors – first advanced by Chapanis[8]-is finally gaining wide acceptance[9]. Human error is not simply the case of one individual making a single mistake; rather it is the product of a design that has allowed the existence and continuation of specific activities which could lead to errors[10].

Human error is an emotive matter. Traditional research has attributed the error to individuals. In recent times, cognitive psychologists have considered the issues of error classification and explanation[11].

According to Reason12, it is necessary to identify the activities of the individual to anything that can go wrong. Thus this approach treats errors as entirely predictable events using an analysis of an individual's activities, rather than an unpredictable occurrence.

The next sequence of applications relates to the use of computing technology for improving the HCI experience. Undoubtedly the former has a direct impact on the latter concerning making it easier for the end-user to utilise technology gainfully to the maximum extent possible

(8) Input Technologies and Techniques

Input devices have been designed to sense the physical properties of people, places and things. However, the fact remains that to use an input device without any visual feedback amounts to using a pen without paper. Input is indivisible from the output, as evident from the proliferation of small-screen devices with integrated sensors.

(9) Sensor and Recognition Based Input for Interaction

Sensors serve the purpose of converting a physical signal into an electronic signal which can be symbolically manipulated on a computer. A wide variety of sensors have been developed for applications as diverse as aerospace, automotive and robotics. Ongoing innovations in manufacturing along with cost reductions have led to such technologies finding uses in consumer products.

(10) Visual Systems

Visual display systems have been a part of civilisation since time immemorial. From the sundials of yore to the first

[8]Chapanis, A. (1999). *The Chapanis Chronicles: 50 years of Human Factors research, Education, and Design.* Santa Barbara, California: Aegean.
[9]Baber, C., & Stanton, N. A. (1994). Task analysis for error identification: a methodology for designing error tolerant consumer products. Ergonomics, 37(11), 1923–1941.
[10]Reason, J. (1990). *Human Error.* Cambridge, UK: Cambridge University Press.
[11]Senders, J. W., & Moray, N. P. (1991). *Human Error.* Hillsdale, NJ: LEA.
[12]Reason, J. (1990). *Human Error.* Cambridge, UK: Cambridge University Press.

analog and digital wristwatches to high-performance wrist computers with high-resolution wrist-worn visual displays, such developments have not only helped to display the time accurately but are also truly multifunctional. Thus some can visualise individual heart rate profiles, others can be used to chart one's precise location on earth with the help of the global positioning system.

(11) Haptic Interfaces

One of the major application areas for HCI has been haptics, involving the use of touch. The sense of touch is undoubtedly inevitable for understanding the real world. One of the suggestions for improving computer-human interaction (CHI) has been the application of force feedback. A haptic interface is a feedback mechanism that involves generating a sensation for the skin and muscles, including a sense of touch, weight and rigidity. In contrast to ordinary visual and auditory sensations, a haptic is more difficult to create. Visual and auditory sensations are created by specialised organs, viz., eyes and ears.

(12) Non-Speech Auditory Input

The human sense of hearing is a very powerful tool. It is possible to obtain a significant amount of information about the surroundings of the sound waves that enter the ears. Sound provides continuous, holistic contact with the environment. The multitude of sounds heard includes familiar sounds, noises of things to avoid as well as noises of things to attend to. Nonspeech sounds-for example music, environmental sounds and sound effects – provide separate information compared to that which emanates from speech; such sounds can be more general as well as ambient, whereas speech is precise and focussed. Nonspeech sounds complement speech just as visual icons complement the text.

(13) Network-Based Interaction

Networks are often treated as mere implementation mechanisms, especially as interfaces are built on them. However, networked interfaces – particularly the internet, as well as mobile devices, have provided a different view of society and the world at large.

Networks can function as enablers, mediators and platforms. There is an extensive range of networking standards, including physical cabling (or even lack of cabling) and the protocols used by computers along with those cables. While most of the wire-based networks have been around for some time, changes in scale and demands of continuous media have meant that they are in a state of constant flux.

(14) Wearable Computers

While computers have become the primary tool for office workers, helping them to access the information needed to perform their jobs, this access to information is more difficult for mobile users. In the case of the existing computer interfaces, the user needs to focus on the computing device, rather than the environment. In a mobile environment, these interfaces may interfere with the primary task of the user. However, many mobile tasks can benefit from computer support.

The designing of wearable computing interfaces requires attention to a variety of factors because of closeness to the body and their use while performing other tasks. The following come into play in this regard:

Corporal

Wearables need to be designed in such a way that they can interface physically with the user without discomfort or distraction.

Attention

Interface design should be such that they permit the user to divide her attention between the physical and virtual worlds.

Manipulation

In the case of a mobile phone-based interface, users lose some of the dexterity that is available in the case of a desktop interface. Consequently controls should be quick to find and simple to manipulate.

Perception

The mobile interface also reduces the ability of the user to perceive displays, both visual and audio. Displays should be simple, distinct and quick to navigate.

On-body computing is also affected by power, heat, on-body and off-heat networking, privacy and many other factors13. Many of these topics are the subject of current research, and much more work is needed for studying how these factors interrelate.

(15) Design of Computer Workstations

Though fixed workstation environments continue to be a significant element of workplace design considerations, these have been overtaken by highly mobile information technology that does not use fixed workstations. Such portable technologies are in use in almost every venue and human activity. The nature of their characteristics and activities of use do not allow the fixed workspace considerations that are traditionally followed. This gives rise to a multitude of potential design based concerns in connection with work areas and activities in which portable information devices and other forms of computing are used. While there has been a substantial amount of research for determining the important considerations for the design of fixed computer work areas, hardly anything has been done with regard to designing work areas personal information devices (PIDs) and mobile computing.

Ergonomics can be described as the science of fitting the environment and activities to the capabilities, dimensions

[13]Starner, T., Snoeck, C., Wong, B., & McGuire, R. (2004) Use of Mobile Appointment Scheduling Devices. *Proceedings of the ACM Conference Human Factors in Computing Systems* (pp. 1501–1504). Los Alamitos, CA: IEEE Computer Society Press.

and needs of people. Ergonomic principles and knowledge can be applied to adapt the working conditions to the physical, psychological and social nature of the person. The obvious goal of this area is to improve performance while enhancing comfort, health and safety. Work area or workstation design can affect employee comfort, health, motivation and performance. A feature of current technologies is that they can interact directly with one another, both with and without human intervention. The variance in environments of use, interaction schemes and activities of use specific make guidance for PIDs difficult and complex.

In closing out this discussion, we would like to consider one of the emerging areas of HCI research, viz., Sustainable HCI (SHCI). In the field of HCI, an important consideration for researchers is the validity of results being presented. Such validity is often achieved through an evaluation process, such as an expert evaluation of a design idea, or a user test with an interactive prototype.

6.Conclusions and Policy Prescriptions

In this paper we have thrown some light on the possible ways in which HCI offers pathways for interaction between humans and computer systems. Accordingly, the relevant applications have been grouped into three groups based on the nature of interactions, viz. – interactions with personal computing devices, touch based devices and public devices. The first has been in development for some time with user comfort and productivity being the guiding factors. Despite the reservations regarding touch based devices, these have been particularly useful for providing accessibility to groups like geriatrics and the specially abled. Finally public devices offer data and accessibility with a user-friendly approach at public locations. These are most suitable for gatherings like conferences and multi-team sporting events. Some of the developments considered here in this connection include perpetual motor interaction; human information processing; incorporating human emotions in HCI; cognitive architecture; task loading and stress; captology; error identification; input technologies; sensor and recognition based inputs; visual systems; haptic interfaces; non-speech auditory input; network based interaction; wearable devices; and workstation design.

The digital revolution has been underway in India for some time. Since the beginning of the new millennium, Indian companies have been able to carve out a niche for themselves, especially in the area of IT services. The present government has laid a lot of stress on initiatives like digitisation of data and the creation of smart cities. In such a climate it is a foregone conclusion that HCI can play a significant role in the forthcoming endeavours as technology gets adopted more rapidly both at the home and the workplace. There should be considerable scope for introducing innovations that encourage better task performance and improved quality of life. In turn, this could facilitate the process of reducing the deficit as far as India's presence in IT manufacturing is concerned. The lack of substantial presence in the manufacturing space in the industry has been a cause for concern for quite some time. This could also have the added effect of a greater number of patents emerging from this country.

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